CLAIMS

1. A method of operating a mass spectrometer, the mass spectrometer including a source of ions, a mass analyzer, and a detector, the method comprising:

calculating a gain of the detector based on intensity measurements for ions having a plurality of different m/z values.

2. The method of claim 1, wherein calculating a gain comprises:

calculating a difference between intensity values for at least two of the ions having different m/z values; and

calculating a gain based at least in part on the difference between intensity values.

3. The method of claim 2, wherein:

calculating a gain based at least in part on the difference between intensity values includes calculating a gain G according to the formula:

$$G = \frac{\sigma_{mD}^{2}}{k * \left(\overline{I_{ma}} + \overline{I_{mb}}\right)}$$

where σ_{mD}^{2} is the square of a standard deviation of the difference, k is a transfer function associated with the detector, $\overline{I_{ma}}$ is a measured average intensity of a single peak corresponding to a first ion of the at least two ions, and $\overline{I_{mb}}$ is a measured average intensity of a single peak corresponding to a second ion of the at least two ions.

4. The method of claim 1, wherein calculating a gain comprises:

calculating a ratio of intensity values for at least two of the ions having different m/z values; and

calculating a gain based at least in part on the ratio of intensity values.

5. The method of claim 4, wherein:

calculating a gain based on the ratio includes calculating a gain G according to the formula:

$$G = \frac{\overline{I_{ma}} * \sigma_{mR}^{2}}{k\left(\overline{I_{mR}}\right)^{2}\left(1 + \overline{I_{mR}}\right)}$$

where $\overline{I_{ma}}$ is a measured average intensity of a single peak corresponding to one of the at least two ions, σ_{mR}^{2} is the square of a standard deviation of the ratio, k is a transfer function associated with the detector, and $\overline{I_{mR}}$ is the ratio of intensity values.

6. The method of claim 1, wherein calculating a gain comprises:

calculating average intensity values and standard deviations for at least two of the ions having different m/z values; and

calculating a gain based at least in part on the these intensity and standard deviation values.

7. The method of claim 6, wherein:

calculating a gain based on the intensity and standard deviation measurements includes calculating a gain G according to the formula:

$$G = \frac{\overline{I_{mb}}^{2}\sigma_{ma}^{2} - \overline{I_{ma}}^{2}\sigma_{mb}^{2}}{k * \overline{I_{mb}} * \overline{I_{ma}}\left(\overline{I_{mb}} - \overline{I_{ma}}\right)}$$

where $\overline{I_{ma}}$ is a measured average intensity and σ_{ma}^{2} is the square of the standard deviation of a single peak corresponding to one of the at least two ions, $\overline{I_{mb}}$ is a measured average intensity and σ_{mb}^{2} is the square of the standard deviation of a single peak corresponding to a second of the at least two ions, k is a transfer function associated with the detector.

8. The method of claim 1, further comprising:

accumulating in the mass analyzer ions generated by a source of ions;

transmitting ions from the mass analyzer to the detector, the ions being selectively transmitted according to their respective m/z values; and

measuring intensity values for the transmitted ions to obtain the intensity measurements for the ions having a plurality of different m/z values.

9. The method of claim 8, wherein:

the source of ions is temporally unstable.

10. The method of claim 8, wherein:

the intensity measurements obtained for ions having at least two different m/z values have a substantially constant instantaneous variation contribution.

11. The method of claim 10, wherein:

the substantially constant instantaneous variation contribution includes a contribution from instability of the source of the ions.

12. The method of claim 8, wherein:

accumulating ions includes accumulating ions generated by the source of ions at substantially the same time; and

measuring intensity values includes measuring intensity values for at least two of the ions generated by the source of ions.

13. The method of claim 8, wherein:

accumulating ions includes accumulating ions for an accumulation time, the accumulation time being selected to optimize the intensity measurements.

14. The method of claim 1, wherein:

the mass analyzer includes a pulsed-type analyzer.

15. The method of claim 1, wherein:

the mass analyzer includes a trapping-type analyzer.

16. The method of claim 1, wherein:

16. The method of claim 1, wherein:

the source of ions includes an ion source selected from the group consisting of atmospheric pressure chemical ionization sources, atmospheric pressure photo-ionization sources, atmospheric pressure photo-chemical-ionization sources, matrix assisted laser desorption ionization sources, atmospheric pressure MALDI sources, and secondary ions ionization sources.

17. The method of claim 1, wherein:

the mass analyzer includes a mass analyzer selected from the group consisting of ion trap mass analyzers, Fourier Transform ion cyclotron resonance mass analyzers, orbitrap mass analyzers, and time of flight mass analyzers.

18. The method of claim 1, wherein:

the detector includes an electron multiplier.

19. A mass spectrometer, comprising:

a source of ions;

a mass analyzer configured to accumulate ions from the source of ions and to selectively transmit the accumulated ions according to their respective m/z values;

a detector configured to receive ions transmitted by the mass analyzer, the detector being operable to generate a signal representing an intensity of ions of each detected m/z value; and

control means operable to calculate a gain of the detector based on intensity measurements for ions having a plurality of different m/z values according to the method of any one of claims 1, 2 or 4.

20. A computer program product on a computer readable medium for operating a mass spectrometer, the mass spectrometer including a source of ions, a mass analyzer, and a detector, the computer program product including instructions operable to cause a programmable processor to perform the method of any one of claims 1, 2 or 4.

21. A method of operating a mass spectrometer, the mass spectrometer including a source of ions, a mass analyzer, and a detector, the method comprising:

calculating the number of ions being detected by the detector based on intensity measurements for ions having a plurality of different m/z values.

22. The method of claim 21, wherein calculating the number of ions detected comprises:

calculating a difference between intensity values for at least two of the ions having different m/z values; and

calculating the number of ions based at least in part on the difference between intensity values.

23. The method of claim 22, wherein:

calculating the number of ions based at least in part on the difference between intensity values includes calculating the number of ions according to the formula:

$$\overline{N_a} = \frac{\left(\overline{I_{ma}}\right)}{\left(\overline{I_{ma}} + \overline{I_{mb}}\right)\sigma_{mD}^{\ 2}}$$

where $\sigma_{mD}^{\ 2}$ is the square of a standard deviation of the difference, $\overline{I_{ma}}$ is a measured average intensity of a single peak corresponding to a first ion of the at least two ions, and $\overline{I_{mb}}$ is a measured average intensity of a single peak corresponding to a second ion of the at least two ions.

24. The method of claim 21, wherein calculating a gain comprises:

calculating a ratio of intensity values for at least two of the ions having different m/z values; and

calculating the number of ions based at least in part on the ratio of intensity values.

25. The method of claim 24, wherein:

calculating the number of ions based on the ratio includes calculating the number of ions N according to the formula:

$$\overline{N_a} = \frac{\left(\overline{I_{mR}}\right)^2\left(1+\overline{I_{mR}}\right)}{\sigma_{mR}^{\;2}}$$

where $\sigma_{mR}^{\;2}$ is the square of a standard deviation of the ratio, and $\overline{I_{mR}}$ is the ratio of intensity values.

26. The method of claim 21, wherein calculating the number of ions comprises:

calculating average intensity values and standard deviations for at least two of the ions having different m/z values; and

calculating a the number of ions based at least in part on the these intensity and standard deviation values.

27. The method of claim 26, wherein:

calculating the number of ions based on the intensity and standard deviation measurements includes calculating the number of ions N according to the formula:

$$\overline{N_a} = \frac{\overline{I_{mb}} * \overline{I_{ma}}^{2}\left(\overline{I_{mb}} - \overline{I_{ma}}\right)}{I_{mb}^{\;2}\sigma_{ma}^{\;2} - I_{ma}^{\;2}\sigma_{mb}^{\;2}}$$

where $\overline{I_{ma}}$ is a measured average intensity and $\sigma_{ma}^{\;2}$ is the square of the standard deviation of a single peak corresponding to one of the at least two ions, $\overline{I_{mb}}$ is a measured average intensity and $\sigma_{mb}^{\;2}$ is the square of the standard deviation of a single peak corresponding to a second of the at least two ions.

28. The method of claim 21, further comprising:

accumulating in the mass analyzer ions generated by a source of ions;

transmitting ions from the mass analyzer to the detector, the ions being selectively transmitted according to their respective m/z values; and

measuring intensity values for the transmitted ions to obtain the intensity measurements for the ions having a plurality of different m/z values.

29. The method of claim 28, wherein:

the source of ions is temporally unstable.

30. The method of claim 28, wherein:

the intensity measurements obtained for ions having at least two different m/z values have a substantially constant instantaneous variation contribution.

31. The method of claim 30, wherein:

the substantially constant instantaneous variation contribution includes a contribution from instability of the source of the ions.

32. The method of claim 28, wherein:

accumulating ions includes accumulating ions generated by the source of ions at substantially the same time; and

measuring intensity values includes measuring intensity values for at least two of the ions generated by the source of ions.

33. The method of claim 28, wherein:

accumulating ions includes accumulating ions for an accumulation time, the accumulation time being selected to optimize the intensity measurements.

34. The method of claim 21, wherein:

the mass analyzer includes a pulsed-type analyzer.

35. The method of claim 21, wherein:

the mass analyzer includes a trapping-type analyzer.

36. The method of claim 21, wherein:

36. The method of claim 21, wherein:

the source of ions includes an ion source selected from the group consisting of atmospheric pressure chemical ionization sources, atmospheric pressure photo-ionization sources, atmospheric pressure photo-chemical-ionization sources, matrix assisted laser desorption ionization sources, atmospheric pressure MALDI sources, and secondary ions ionization sources.

37. The method of claim 21, wherein:

the mass analyzer includes a mass analyzer selected from the group consisting of ion trap mass analyzers, Fourier Transform ion cyclotron resonance mass analyzers, orbitrap mass analyzers, and time of flight mass analyzers.

38. The method of claim 21, wherein:

the detector includes an electron multiplier.

39. A mass spectrometer, comprising:

a source of ions;

a mass analyzer configured to accumulate ions from the source of ions and to selectively transmit the accumulated ions according to their respective m/z values;

a detector configured to receive ions transmitted by the mass analyzer, the detector being operable to generate a signal representing an intensity of ions of each detected m/z value; and

control means operable to calculate the number of ions detected by the detector based on intensity measurements for ions having a plurality of different m/z values according to the method of any one of claims 21, 22 or 24.

40. A computer program product on a computer readable medium for operating a mass spectrometer, the mass spectrometer including a source of ions, a mass analyzer, and a detector, the computer program product including instructions operable to cause a programmable processor to perform the method of any one of claims 21, 22 or 24.